Electronic Supplementary Material (ESI) for Nanoscale.

Supporting Information

Homogeneous Platinum Diselenide Metal/Semiconductor Coplanar Structure Fabricated by Selective Thickness Control

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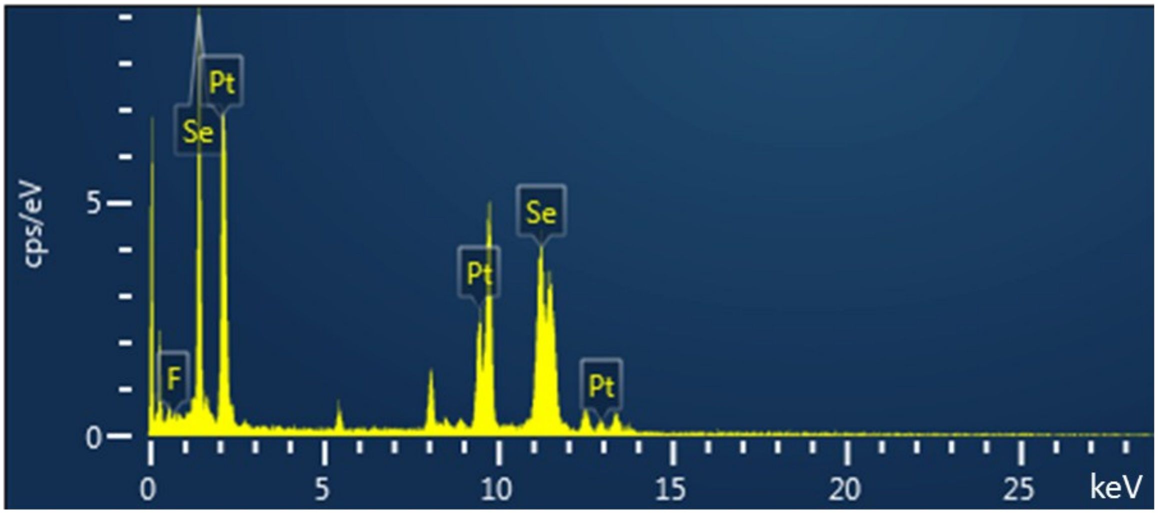

Fig. S1. EDS profile of plasma-treated $PtSe_2$ flakes.

ICP was employed to etch $PtSe_2$ flakes using a mixture of Ar and SF_6 as the gas source. The chemical reaction between SF_6 and $PtSe_2$ generated volatile byproducts, leading to the etching of $PtSe_2$. The EDS of the ICP-treated $PtSe_2$ was carried out, and the results are shown in Fig. S1. The atomic percentage of F is almost 0%, which confirms that F does not remain on the surface of the ICP-treated $PtSe_2$. Moreover, no chemical byproducts adhered to the surface of the ICP-treated $PtSe_2$.

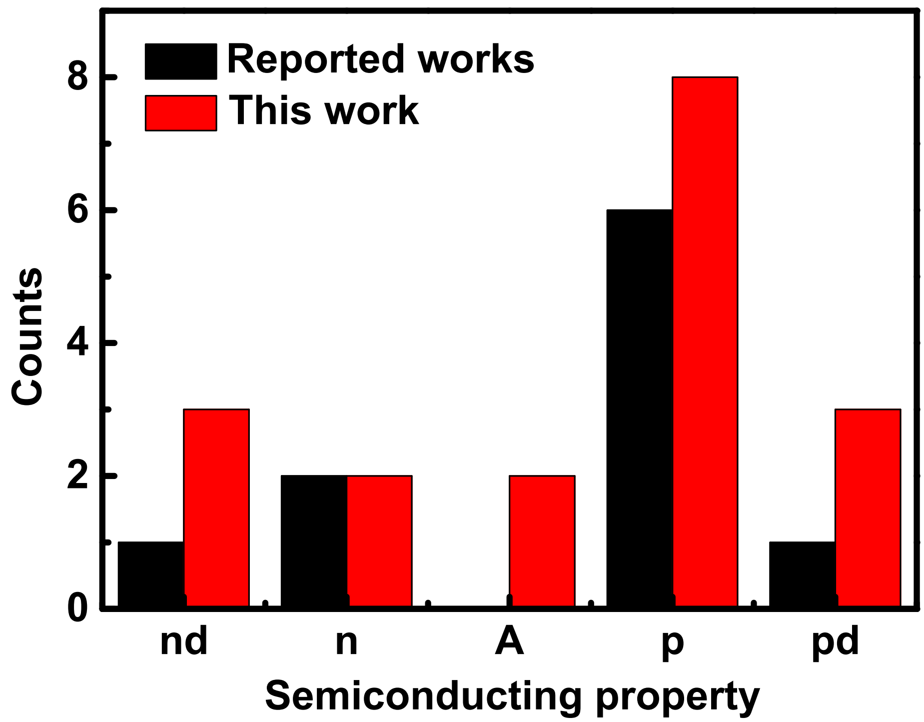

Fig. S2. Distribution of semiconducting properties of $PtSe_2$ devices ($I_{on}/I_{off}>2$). (nd[1]: n-type dominant; n[2, 3]: n-type; A: ambipolar; p[4-9]: p-type; pd[10]: p-type dominant)

Fig. S2 demonstrates the distribution of $PtSe_2$ semiconducting properties, including previously reported studies and ours. Different semiconducting properties were obtained for the reported studies and ours, where p-type is the dominant property. For the sake of a clear understanding of this phenomenon and precise control of semiconducting properties of $PtSe_2$, a further study is needed.

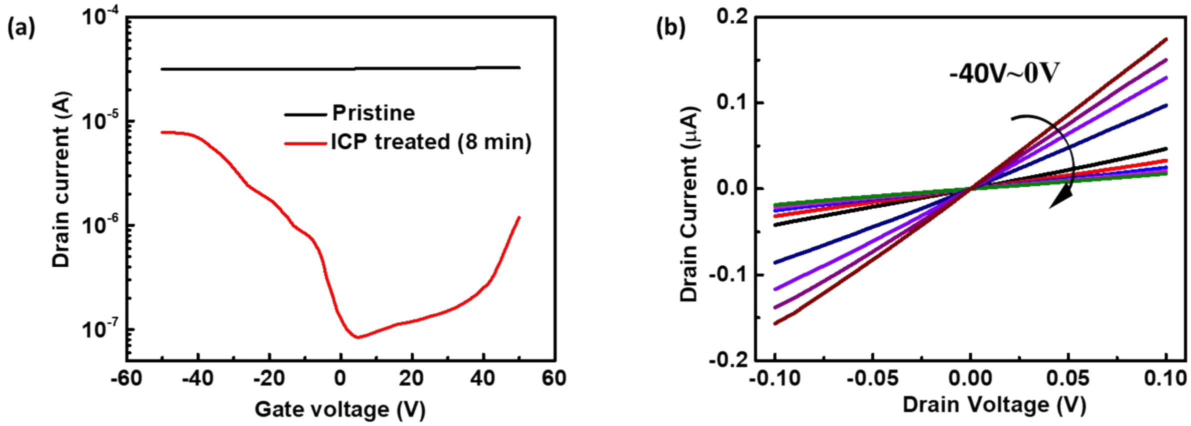

Fig. S3. (a) I_d-V_g curves of pristine and ICP-treated $PtSe_2$ devices. (b) I_d-V_d curves of plasma-treated $PtSe_2$ device.

Fig. S3a shows the I_d-V_g curves of the pristine and ICP-treated $PtSe_2$ devices. Before the ICP treatment, the pristine $PtSe_2$ device with a thickness of 9 nm shows a metallic property, whereas after the ICP treatment, the thickness of $PtSe_2$ decreased to 3 nm and it exhibited a semiconducting property. The I_d-V_d curves under different gate voltages (Fig. S3b) proved the semiconducting property of $PtSe_2$ after the ICP treatment. Moreover, the I_d-V_d curves demonstrate super linearity, confirming the ohmic contact between the $PtSe_2$ channel and electrode.

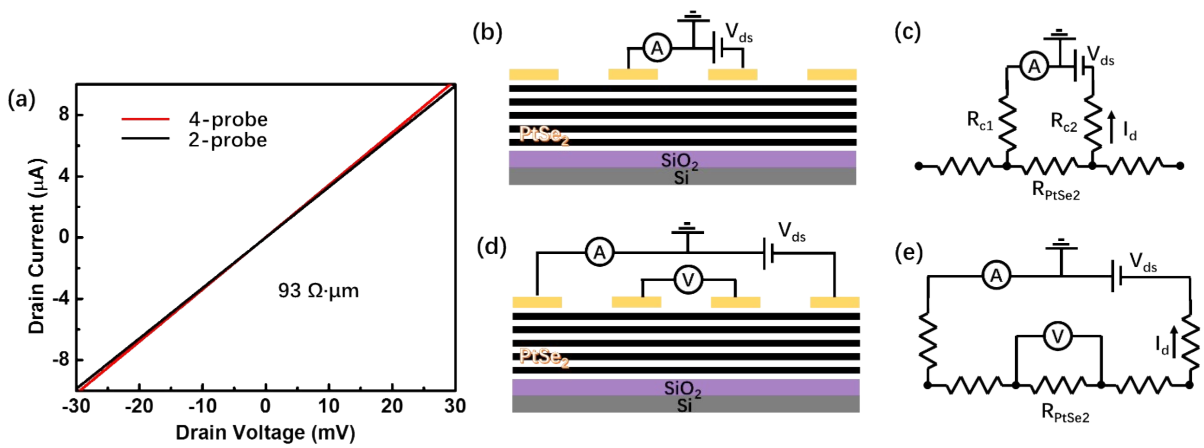

Fig. S4. (a) Extraction of contact resistance of a metallic pristine $PtSe_2$ device by 4-probe measurements. Schematic (b) and circuit diagram (c) for 2-probe measurements. Schematic (d) and circuit diagram (e) for 4-probe measurements.

The contact resistance between the metallic $PtSe_2$ and Au layer was determined by 2-probe and 4-probe measurements; the result is shown in Fig. S4, which shows the measurement configurations of the contact resistance between the metallic $PtSe_2$ and Au layer. First, 2-probe measurements using the inner two electrodes (Fig. S4b) were conducted. The total resistance was evaluated from the drain current I_d and applied voltage V_{ds}, including the $PtSe_2$ resistance (R_{PtSe2}) between the two inner electrodes and the contact resistance at those inner electrodes (R_{c1}+R_{c2}). Then, 4-probe measurements were performed, as shown in Fig. S4d and S4e, where V_{ds} was applied between the outer electrodes and the voltage between the two inner electrodes was measured; R_{PtSe2} was obtained from the measured values of V_{ds} and $I_{d.}$ Finally, the contact resistance was extracted from the difference between the total resistance and R_{PtSe2}. The contact resistance was found to be 93 Ω·µm, which is consistent with the reported value.[3]

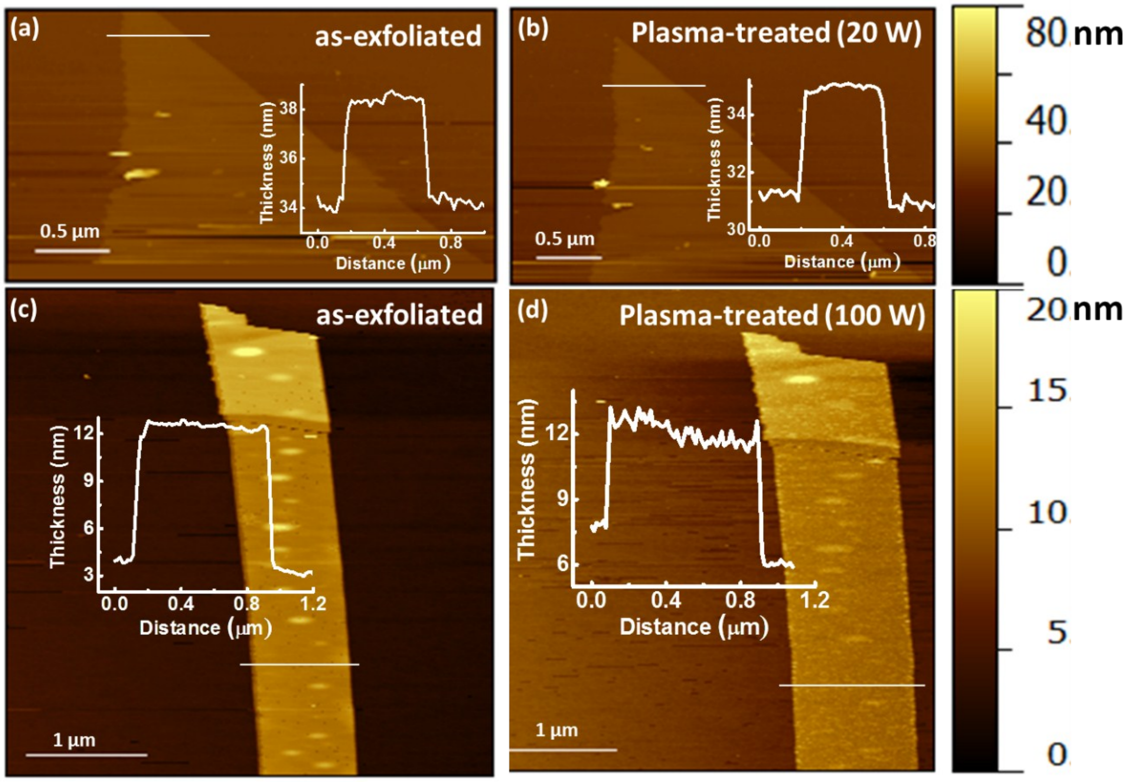

Fig. S5. AFM images of as-exfoliated $PtSe_2$ flakes (a and c) and plasma-treated $PtSe_2$ for 3 min with a power value of 20 W (b) and 100 W (d). The $PtSe_2$ flake in (b) was treated by ICP at 20 W. The $PtSe_2$ flake in (d) was treated by ICP at 100 W.

Fig. S5a and S5c show the as-exfoliated $PtSe_2$ flakes without ICP treatment. After ICP treatment at 20 W, the $PtSe_2$ flakes were not etched and kept their original thickness, as shown in Fig. S5b. However, when the $PtSe_2$ flakes were treated by ICP at 100 W, surface damage was induced, as shown in Fig. S5d. To control the PtSe2 thickness without inducing surface damage, the optimal ICP power condition in our study was found to be 25 W.

Table S1. Mobility and I_{on}/I_{off} ratio of $PtSe_2$ flakes with different thicknesses.

Thickness [nm]	**11**	**7**	**5**	**3**
I_{on}/I_{off}	2.5	6.9	12	93
Mobility [$cm^2V^{-1}s^{-1}$]	444	320	300	150

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